FORT MACKAY SETTLEMENT WATER SUPPLY REPORT

By

Kerr, P. Eng. Soils, Geology and Groundwater Branch
Shillabeer, P. Eng. Environmental Health Services Division

FORT MACKAY SETTLEMENT

WATER SUPPLY REPORT

At the request of the Human Resources Development Authority, an investigation of all potential water supplies for the Settlement of Fort MacKay was conducted on May 7, 1969 by the following Professional Engineers:

H.A. Kerr	-	Soils, Geology and Groundwater Branch Water Resources Division Department of Agriculture
J.D. Bredin	-	Provincial Planning Branch Department of Municipal Affairs
D.A. Shillabeer	-	Municipal Engineering Section Environmental Health Services Division Department of Health

SUMMATION

At the present time, most of the residents in the settlement (population approximately 250) utilize surface runoff and rainwater for drinking purposes during the summer months. Melted snow is used during the winter. The Hudson Bay Company Store and Residence has its own shallow well and pressure system, whereas the school pumps water from the Athabasca River into a cistern, allows it to settle, and chlorinates prior to consumption.

The people of Fort MacKay need a better supply of water. It is the writers' opinion that such a supply must be located in the settlement proper near a place where the majority of the inhabitants will pass. The supply must be safeguarded against pollution or be easily purified. Any system must be simple to operate.

It is recommended that the first consideration should be to determine the feasibility of a deep groundwater supply from the Beaverhill Lake limestone Formation. If this is not suitable; a surface water storage and treatment system utilizing the Athabasca River is the recommended alternative.

Details of the geology of the area, various possible water sources and cost comparison of a well supply and surface reservoir are provided on the following pages.

GEOLOGY OF AREA

Depth	Formation	Description
up to 40 ft.	Pleistocene and recent	Gravel, till and post glacial deposits of silt and sand.
40' - 80'	McMurray	Fine to coarse sand and gravel. The sands are oil bearing.
80' up to 500' ?	Beaverhill Lake	Fossiliferous limestone interbedded with shale layers. The limestone is well jointed and commonly fractured; the fractures are often filled with bitumen.

The bedrock and oil sands are exposed throughout the Fort MacKay area. A thin film of oil could be observed on all water supplies tested. Fossiliferous limestone containing thin shale beds were found north of the Hudson Bay Company Store, along the Athabasca River. These were overlain by the oil sands. The shale appeared to be bentonitic and was wet at a number of places. The limestone shale sequence extends under the Athabasca River.

EXISTING WATER SOURCES - EVALUATION

All the possible sources of water in the settlement were carefully examined and both chemical and bacteriological water samples were obtained. A tabulation of the results of the analysis of these samples is attached in Appendix I and II. As indicated, all the waters tested were quite colored, very hard, contained oils and greases, and most had high iron contents.

Field experimentation showed that the iron content could be reduced by aeration and chlorination and that the color could be removed by charcoal filtration. This method of treatment also produced a water with no appreciable taste.

A. GROUNDWATER

1) School Well

In 1968, the Department of Municipal Affairs had a well constructed on the Northland School Division property. The well is 82 feet deep and a short pumping test established that the safe production rate was only 2 gallons per minute. A submersible pump is installed in this well; this pump was apparently oversized as evidenced by the fact that the well would pump for several seconds and then take 5 to 10 minutes to recharge.

Two Jacuzzi Hydrocells have been instaled in the pumphouse but these are not connected to the well or to any distribution system. The well pumps onto the ground outside of the pumphouse. There is no meter or drawdown gauge on the well.

The high solid content, turbidity, and oils and greases may be due to the fact that this well was pumped at too high a rate.

This well is not considered to be a practical source due to the low yield, poor chemical quality, and distance from the main part of the settlement.

2) Hudson Bay Company Well

The flowing artesian well in the basement of the Hudson Bay Store was inspected in company with Mr. James Faichney, the local agent. Water from the well (cased by a 4 foot culvert) is passed through a Hagan Model HIS2C Wellhead Filter prior to entering the pressure system. The agent objects to the iron present in the water but otherwise has no complaints regarding the quality of this supply.

The high nitrate content and the relatively high chlorides could be an indication that this well may be contaminated. The uncertainty of any yield

determination (due to the shallow aquifer and unknown recharge area), poor quality and the distance from the main settlement are additional factors leading to the exclusion of this as a supply.

3) Forestry Well

In 1968, Municipal Affairs drilled a second community well located on the Lands and Forests site. The production from this well was estimated to be 8 to 10 gallons per minute; however, at the time of the inspection a pump had not been installed.

It is doubtful if a shallow well of this type could maintain a sufficient yield for 250 persons. The 1968 production estimate was not based upon established pump test procedures. Therefore, the uncertainty of any yield determination, water quality and the distance of the well from the center of the community would dictate that no further consideration of this source be given.

B. SURFACE WATER

1) Athabasca River

The Athabasca River has the advantage of being the closest year-round surface water supply to the settlement. Chlorination, settling and filtration should produce an acceptable drinking water from this source. The Athabasca River water is also the best quality water currently known in the area.

A detailed evaluation regarding the utilization of the Athabasca is presented in a following section.

2) Fort MacKay River

This river also would provide a year-round supply of sufficient quantity but its location (approximately one-half mile south of the settlement) would increase the cost of the system over using the Athabasca as a supply and therefore it is not considered further.

3) Beaver River

This river, which is about 5 miles south of the settlement, was not considered due to the cost of a supply main.

4) Muskeg Runoff - North of Settlement

A small drainage course at the north end of the settlement carries run-off from a muskeg area during the spring and early summer. This water is used by a large percentage of the native population during this period. At the time of the inspection, the flow was estimated to be approximately 15 gallons per minute.

The development of this source is reviewed in detail later in the report.

5) Muskeg Runoff - South of Fort MacKay River

Another drainage course carrying muskeg runoff is located just to the south of the Fort MacKay River. This supply has been utilized by the school during periods when the Athabasca River supply pump was in-operative. The flow was estimated to be from 30 to 40 gallons per minute at the time of the inspection. The location of this supply renders it unsuitable.

DETAILED EVALUATION OF RECOMMENDED SOURCES

Of all the sources evaluated in the previous section, none of the existing wells and only two of the surface supplies appeared to merit further consideration, namely the Athabasca River and the north muskeg runoff. In addition to these, the development of a deep well will also be reviewed.

In selecting those sources for further consideration, the following criteria was used:

1) Location - The supply must be located near the center of the community such that the residents will utilize this water in preference to other sources. Consideration must also be given to avoiding potential sources of pollution.

2) Quality - The proposed supply must be of adequate chemical, bacteriological, and physical quality. The treatment facilities required to produce such a water must be economical and easy to operate.

3) Quantity - The proposed supply must be able to provide at least 20 gallons per capita per day for the 250 residents of the community.

4) Cost - The cost of production, treatment and storage facilities must be kept to a minimum and the system must be economical to operate.

I. Deep Well in Beaverhill Lake Formation

There is a distinct possibility that a deep groundwater well into the Beaverhill Lake limestone Formation would provide a water supply in accordance with the above noted criteria. It is known that a well can meet the requirements regarding location, cost, operation and maintenance; however, a test hole would be required to establish the quantity and quality.

Testhole

A testhole along the river in the main settlement would provide all the data needed for estimating the amount and quality of groundwater available from the limestone formation. A testhole drilled into the limestone with casing installed below a thick shale layer would be the best approach. The shale layer might provide a parrier to the downward movement of oil from the McMurray Formation. Slow recharge is likely available from the Athabasca River. Such a testhole would provide additional information to other Departments, as to date no deep testholes have been drilled in the area.

Estimated Cost of Testhole

Mobilization	$ 500.00
Testhole drilled to 300 feet	$ 600.00
Casing - installed	$ 800.00
Development	$ 500.00
Pump Test	$ 500.00
Supervision	$ 500.00
Miscellaneous	$ 600.00
	$4000.00

Production Well

Upon completion of the pump test, a decision regarding the feasibility of constructing a production well can be made. Equipment required would be a pump and related piping, all-weather pumphouse, power supply, and storage facilities. In addition, an iron removal unit will most probably be required to remove the excess iron present in the water taken from the limestone.

Estimated Cost of Production Well

Pump and related piping (installed)	$2000.00
All-weather Pumphouse	$1000.00
Power Supply	$ 250.00
Storage Tank (1000 gal.)	$ 500.00
Iron Removal	$2000.00
Miscellaneous	$1000.00
	$6750.00

In addition to the above, a water softener at an estimate cost of $1500.00 may be required.

Operating Costs

It is assumed that the local Forestry Officer will be responsible for the day-to-day operation and maintenance of this system; therefore, no labor costs will be incurred.

Power	$ 150.00
Heating	$ 200.00
Iron Removal	$ 150.00
Water softener salt	$1200.00
Miscellaneous	$ 300.00
	$2000.00

Summary of Costs

Testhole	$4000.00
Production Well	$6750.00
Water Softener	$1500.00
	$12250.00
Annual operating cost -	$2000.00

II. Surface Water Supply

A second alternative is the development of a surface water supply storage and treatment system utilizing either the Athabasca River or muskeg runoff at the north end of the settlement. Either source would require the construction of a large storage reservoir to hold a sufficient quantity of water to supply the community for at least one year. The solids content, turbidity, color, and iron content would be reduced by settling in the reservoir. Filtration (pressure sand filter) and chlorination will also be required prior to consumption. The most suitable location for the reservoir would be on the west side of the main road (1,000 feet from the river) along the muskeg drainage course.

(a) Athabasca River

The grab sample obtained from the bank of the Athabasca River at the time of the inspection does not appear to be representative of the river quality as outlined in Appendix II. The average total hardness of a series of six samples taken approximately 25 miles upstream of the settlement was 152 parts per million.

A reservoir approximately 225 feet square at water surface and 20 feet deep would provide 3.6 million gallons storage capacity. The reservoir should be surrounded by a chain link fence topped with barbed wire to prevent unauthorized entry to the site.

The reservoir would be filled on an annual basis with the water being taken during the fall months when the solids content in the river water is at the lowest level. A plastic supply line to the reservoir would be buried in a shallow ditch. A 600 gallon per minute diesel driver portable pump would be used to fill the reservoir; approximatey 1 week's pumping would be required.

Estimated Cost of Pump and Supply Line

Pump and Diesel Engine	$ 4,000.00
Supply Line (1,000 feet)	$ 3,000.00
	$ 7,000.00

Estimated Cost of Reservoir

Earthwork	$10,000.00
Fencing	$ 3,500.00
Inlet and Outlet Piping	$ 500.00
Land Aquisition	$ 300.00
Miscellaneous	$ 1,700.00
	$16,000.00

Estimated Cost of Pumphouse and Treatment Facilities

All-weather Pumphouse	$ 1,000.00
Power Supply	$ 250.00
Storage Tank (1,000 gal.)	$ 500.00
Pressure Sand Filer with Pump	$ 800.00
Chlorinator and Solution Containers	$ 700.00
Equipment Installation and related piping	$ 300.00
Miscellaneous	$ 450.00
	$ 4,000.00

Additional Costs

Soil testing should be carried out at the proposed reservoir site before construction commences. If the soils are unsuitable for reservoir construction, dugout lining (plastic) will have to be considered.

Soil testing program	$ 1,000.00
Reservoir lining	$ 4,000.00
	$ 5,000.00

Operating Costs

Power	$ 150.00
Heating	$ 200.00
Labor - Filling reservoir	$ 300.00
Miscellaneous	$ 100.00
	$ 750.00

Summary of Costs

Pump and Supply Line	$ 7,000.00
Reservoir	$16,000.00
Soil testing and Reservoir Lining	$ 5,000.00
Pumphouse and Treatment facilities	$ 4,000.00
	$32,000.00
Annual operating cost -	$ 750.00

(b) Muskeg Runoff - North of Settlement

As previously noted, the best location for the surface water storage reservoir would be on the west side of the main road and along the muskeg drainage course at the north end of the settlement. The reservoir could be constructed such that the muskeg runoff might be collected. A brief hydrology survey of the watershed would have to be carried out to evaluate the amount of runoff available before this alternative could be selected.

The estimated costs for a system utilizing this source would be quite similar to the Athabasca River system. The cost of the supply pump and pipeline and labor for filling the reservoir would be deleted but additional monies would be required for the hydrology survey, barbed-wire fencing of a portion of the drainage course and the construction of an inlet structure. Quality of the water would not be as satisfactory as utilizing the Athabasca River.

Estimated Cost of Reservoir and Related Works

Earthwork	$10,000.00
Reservoir fencing	$ 3,500.00
Drainage course fencing	$ 1,000.00
Outlet Piping	$ 300.00
Land Aquisition	$ 300.00
Inlet structure and diversion works	$ 2,000.00
Miscellaneous	$ 1,900.00
	$19,000.00

Estimated Cost of Pumphouse and Treatment Facilities

All-weather Pumphouse	$ 1,000.00
Power supply	$ 250.00
Storage Tank (1000 gal.)	$ 500.00
Pressure Sand Filet with Pump	$ 800.00
Chlorinator and Solution Containers	$ 700.00
Equipment Installation and related piping	$ 300.00
Miscellaneous	$ 450.00
	$ 4,000.00

Estimated Additional Costs

Soil Testing Program	$ 1,000.00
Reservoir Lining	$ 4,000.00
	$ 5,000.00

Operating Costs

Power	$ 150.00
Heating	$ 200.00
Miscellaneous	$ 200.00
	$ 550.00

Summary of Costs

Hydrology Survey	$ 1,000.00
Reservoir and Related Works	$19,000.00
Pumphouse & Treatment facilities	$ 4,000.00
Soil Testing & Reservoir lining	$ 5,000.00
	$29,000.00
Annual operating costs	$ 550.00

DISCUSSION

The various advantage and disadvantages of the respective alternatives can best be shown by the following table:

DEEP WELL	ATHABASCA RIVER	MUSKEG RUNOFF
	ADVANTAGES	
1) Most economical	1) Assured year-round supply	1) Lower cost than Athabasca River
2) Easily maintained if iron removal and softing not required	2) Iron removal and softening not required	2) Iron removal and softening not required
3) Can be located at optimum site	3) Highest quality (lowest hardness, oil and greases)	
4) Constant quantity and quality		
5) Chlorination should not be required.		
	DISADVANTAGES	
1) Testhole may show suitable groundwater not available (quantity and quality)	1) Most costly	1) Second highest cost
2) Iron removal and softening will probably be required.		2) A limited period to fill reservoir
3) Highest operating cost		3) Yearly variations in quantity of runoff
		4) Reservoir subject to pollution
		5) High color

TABLE OF COSTS - DOLLARS

System	Capital Costs Total Cost	 Annual (8%-20yrs)	Annual Operating Cost	Total Annual Cost
Deep Well				
- with softening	12,250.	1,250.	2,000.	3,250.
- without softening	10,750.	1,095.	800.	1,895.
Athabasca River	32,000.	3,260.	750.	4,010.
Muskeg Runoff	29,000.	2,955.	550.	3,505.

Due to cost factors, the development of a deep well water supply is suggested as the first step. For an investment of $4,000. the feasibility of this source can be accurately evaluated. If the well proves to be unsatisfactory, a surface system utilizing the Athabasca River is the best alternative. Although it is slightly higher in cost, the Athabasca is selected in preference to the muskeg·runoff due to a superior chemical quality and an assured year-round supply.

It should be noted that the testhole at Fort MacKay will provide valuable information for future reference.

It is felt that this report presents a realistic evaluation of the works and cost involved in developing a suitable water supply for For MacKay. However, it is strongly recommended that a detailed design analysis and final cost estimates be prepared by a firm of Consulting Engineers experienced in the water supply field before work proceeds.

RECOMMENDATIONS

In order to develop an adequate safe water supply for the Settlement at Fort MacKay, it is recommended that the following procedure be followed:

1) Drill a testhole to evaluate the quantity and quality of water available from the Beaverhill Lake Formation.

2) If the aquifer analysis proves a suitable supply, complete the construction of a production well.

3) If a well supply is not available, construct a surface water storage and treatment system utilizing the Athabasca River.

Prepared By:

PROFESSIONAL ENGINEER ALBERTA
HUGH A. KERR

H.A. Kerr, M.Sc. P. Eng.
Groundwater Engineer
Soils, Geology and Groundwater Branch

PROFESSIONAL ENGINEER ALBERTA
D. A. SHILLABEER

D.A. Shillabeer, B.Sc. P. Eng.
Environmental Health Service Division

FORT MACKAY SETTLEMENT - WATER ANALYSIS - MAY 7, 1969

Analytical Results / Sampling Location	Units	Limits Recommended	Limits Acceptable	School Well A - 1	H.B.C. Well A - 2	* Athabasca River B- 1	Ft. MacKay River B - 2	Beaver River B - 3	Muskeg Runoff North of Settlement B - 4	Muskeg Runoff South of MacKay River B - 5	School Cistern
Total Coliforms	MPN/100ml	Neg	Neg	Neg	cNeg	11.0	4.5	7.8	2.2	Neg	2.2
E. Coli	MPN/100ml	Neg	Neg	Neg	Neg	4.0	4.5	7.8	Neg	Neg	Neg
Standard Plate Count	bacteria/ml		3,000	12,000	18,000	5,100	1,500	5,000	13,000	8,500	6,500
pH	--	7.5 - 8.5		7.4	7.2	8.0	7.7	8.0	7.4	8.1	8.1
Total Alkalinity (as $CaCO_3$)	ppm			279	66	57	48	66	109	138	70
Threshold Odor Type	--	M-Musty		C	C	M	M	M	M	M	M
Threshold Odor Number	--	C-Chemical Not objectionable		50	8	4	8	2	4	2	4
Oil and Grease	pp	Nil		52.8	0.9	1.9	1.9	1.3	2.9	13.7	1.6
Chlorides	ppm	250		5	28	2	2	2	5	2	9
Total Phosphates	ppm			4.6	0.30	0.68	0.43	0.23	0.13	0.10	0.25
Total Iron	ppm	0.3		2.4	2.6	2.0	1.3	1.1	0.3	0.3	1.2
Ammonia-Nitrogen	ppm			0.72	0.52	1.28	1.6	1.9	1.8	1.2	1.48
Nitrate-Nitrogen	ppm		10	0.21	5.8	0.17	0.19	0.26	0.22	0.14	0.22
Sulfates	ppm	250		28	26	20	12	4	4	0	28
Total Hardness (as $CaCO_3$)	ppm	100	400	2680	960	720	580	700	920	1160	760
Calcium Hardness ($CaCO_3$)	ppm			2100	900	540	420	500	760	820	640
Fluorides	ppm	1.00		0.09	0.10	0.15	0.05	0.35	0.14	0.11	0.11
Total Residue	ppm	500	1000	3274	268	346	282	178	198	226	204
Ignition Loss	ppm			558	164	118	148	126	150	152	106
Total Suspended Solids	ppm			3050	18	228	130	8	10	6	18
Ignition Loss	ppm			335	16	18	10	6	8	6	8
Turbidity	ppm	10		880	46	55	35	10	3	3	35
Color	Hazen Color Units	20		27	230	88	84	80	92	60	75

* See Apprndix II

APPENDIX II

ATHABASCA RIVER BELOW FORT MCMURRAY

ANALYSIS OF MONTHY SAMPLES TAKEN OCTOBER, 1968 TO MARCH, 1969 - AVERAGE

(Sampled by Water Pollution Control Section - Environmental Health Services Division)

pH		7.8
Alkalinity	ppm	132
Total Residue	ppm	280
Ignition Loss	ppm	88
Turbidity SiO_2	ppm	17
Total Hardness	ppm	152
Chlorides	ppm	22
Ammonia Nitrogen	ppm	0.44
Nitrate Nitrogen	ppm	0.12
Sulphates as SO_4	ppm	54
Total Phosphates	ppm	0.06
Oils and Greases	ppm	1.58
Fluorides	ppm.	0.16
Phenols	ppb	5.4
Color	Hazen Units	50

September 19, 1969

Mr. J.E. Oberholtzer
Director
Human Resources Development Authority
Legislative Bldg.
Edmonton, Alberta.

Dear Sir:

The following is a summary of the work done on the Fort MacKay Drilling Program.

As you know, the drilling was tendered for bids, but none were received. Consequently, we telephoned several drillers, and finally obtained a bid from Elk Point Drilling. This bid was accepted, although somewhat higher than we had anticipated.

Mr. Nielsen and the contractor left Edmonton on Wednesday, September 10th. The contractor arrived the next morning and started drilling in the afternoon. By 3:00 P.M. on September 11th, the test hole was 513 feet deep with no permeable zones indicated, except at 437 - 457 feet. At the depth of 513 feet, the drilling mud started flowing from the hole, then suddenly it was all blown out by natural gas. The gas blow continued about a half-hour, then gradually died down. The contractor was able to regain control of the well and electric log it previous to cementing it off. The bottom 100 feet was cemented to ensure that the gas could not escape again.

The electric log confirmed the presence of permeability from 437 to 457 feet, and suggested more at the bottom. Although water, if present, would normally have been blown out with the gas, none was seen. Yet the permeability did indicate that water should be present, perhaps only in small quantities.

It was decided that if the program were terminated, we would still be unsure as to whether or not we had passed up a potential water supply. The only way to be sure was to drill a second hole deep enough to encounter the permeable zone, but stop well short of the depth at which gas was encountered.

.......2

This was done, the well being drilled only seven feet into the permeable zone. The well was then flushed clean of drilling mud to make it possible to bail out any water which might be present. Even at this depth, a small gas flow occurred, suggesting that the original gas blow was also from this depth.

It was then decided to cement this well also, and terminate the program, for two reasons:

1. If gas was trapped, then deeper water, if any, would be trapped also, and would be very highly mineralized from its long residence time in the ground.

2. An old well exists one-half mile north which is only 102 feet deeper (615 feet), and flows water which has been analysed as twice as salty as sea water.

There was nothing to be gained from drilling in another location, as the only change of geology would be a thicker section of oil sands. Lands and Forests already own a well bottomed in oil sands and the water is extremely high in iron and hydro-carbons. It is not being used for this reason.

The remaining alternatives for a village water supply are those suggested by Messrs. Kerr and Shillabeer as a result of their inspection in May, 1969: collection of muskeg runoff into a dugout, or pumping of Athabasca river water into a dugout. Both of these alternatives would require treatment facilities.

A complete test hole summary is being prepared and will be sent to you as soon as possible.

The contractor has not yet submitted his bill, but it will be approximately $6700. as nearly as we can tell at present.

Yours truly,

G.L. Nielsen, P. Geol.
Hydrogeologist
(for) L.D.M. Sadler, P. Ag.
Branch Head
Soils, Geology and Groundwater Branch

GLN:ef

October 1, 1969

Mr. J.E. Oberholtzer
Director
Human Resources Development Authority
Legislative Building
Edmonton

Dear Sir:

Enclosed please find the well summary and electric logs from our test-holes at Fort McKay.

Elk Point Drilling has submitted their bill, which is now being processed. The total cost was [illegible].

With the drilling we have done and that done previously by Municipal Affairs, it is now obvious that a groundwater source is not possible for this area. To establish any sort of community water supply, surface water will be necessary. The pros and cons of the several remaining alternatives are outlined in Messrs. Shillabeer and Kerr's report.

Yours truly,

[illegible] Nielsen, [illegible] Geol.
Hydrogeologist
Soils, Geology and Groundwater Branch
(for) [illegible] Bailey, [illegible]
Director
Water Resources Division

cc. [illegible] Bailey
W. Solodzuk
[illegible]

[illegible]

[illegible]

FORT MACKAY TEST HOLE SUMMARY

Location:	Lsd 11-25-94-11-W4
Starting Date:	September 11, 1969
Completion Date:	September 16, 1969
Elevation:	825 feet (est., from topographic map not surveyed)
Total Depth:	513 feet
Tests:	None
Status:	Dry and abandoned
Gas:	Strong blow of sweet gas occurred while drilling at 513 feet; source was 437 - 457 feet (Slave Point).

Formation tops:

	Depth	Elev. (M.S.L.)
Pleistocene	0	825
Devonian		
Beaverhill Lake fm.		
(Moberly mem)	4	+ 821
(Christina mem)	84	+ 741
(Calumet mem)	166	+ 659
(Firebag mem)	262	+ 563
Watt Mountain	385	+ 440
Slave Point	431	+ 394
Dawson Bay	457	+ 368
Anhydrite	500	+ 325

Abandonment Details: Cemented 400' - 500', used 15 sacks of cement

FORT MACKAY TEST HOLE SUMMARY

Well Name:	Agric. Ft. MacKay D.W. 11-25-94-11
Location:	Lsd. 11-25-94-11-W4
Starting Date:	September 11, 1969
Completion Date:	September 16, 1969
Elevation:	825 feet (est., from topographic map - not surveyed)
Total Depth:	513 feet
Tests:	None
Status:	Dry and abandoned
Gas:	Strong blow of sweet gas occurred while drilling at 513 feet; source was 437 - 457 feet (Slave Point)

Formation Tops:

	Depth	Elev. (M.S.L.)
Pleistocene	0	825
Devonian		
Beavergill Lake Fm.		
(Moberly mem.)	4	+ 821
(Christina mem.)	84	+ 741
(Calumet mem.)	166	+ 659
(Firebag mem.)	262	+ 563
Watt Mountain	385	+ 440
Slave Point	431	+ 394
Dawson Bay	457	+ 368
Anhydrite	500	+ 325

Abandonment Details: Plug No. 1 400' - 500', used 15 sacks of cement

SAMPLE LOG

Interval	Description
0 - 10	Clay, lt gy, bent; abnd Fe st
10 - 20	Sh, lt gy, bent, sft, calc
20 - 30	Sh, v lt gy, a a, frac filled with lt yel calcite
30 - 40	Sh, a a, Sand, c-v cse, strong oil stn, qtz, w rd
40 - 50	Ls, wht, sl arg, micrxl, live oil stn
50 - 60	Ls, wht, micrxl, fos, live oil stn
60 - 70	Ls, a a, no oil stn
70 - 80	Ls, a a
80 - 90	Sh, lt gy, v sft, bent, calc
90 - 100	Sh, aa / Ls, lt gy, micrxl, fos, sl arg.
100 - 110	Sh, lt gy, sft, v calc
110 - 120	Ls, mgy, mxl, lt bf, in pt, arg ptgs
120 - 130	Sh, lt gy, sft, fis, v calc
130 - 140	Sh, lt gn-gy, sft, calc
140 - 150	Sh, a a
150 - 160	Sh, a a
160 - 170	Sh, a a / Tr. Ls, lt bf, mxl, sl fos
170 - 180	Sh, aa
180 - 190	Ls, lt gy, micrxl, v arg, sl fos
190 - 200	Ls, lt bf, v f xl, sacch, sl fos in pt
200 - 210	Sh, lt gn-gy, sft, fis, calc, waxy
210 - 220	Sh, a a
220 - 230	Sh, a a
230 - 240	Sh, a a
240 - 250	Sh, lt gy, sft, fis, sl calc
250 - 260	Sh, a a / Ls, lt-m gy, f xl, fos
260 - 270	Sh, a a
270 - 280	Sh, lt gy-gn, sft, fis, calc, waxy
280 - 290	Sh, a a
290 - 300	Sh, a a
300 - 310	Ls, lt gy-bf, f xl, sacc in pt / Tr sh, a a
310 - 320	Sh, a a
320 - 330	Sh, a a
330 - 340	Sh, a a
340 - 350	Sh, a a, with wht cal & pyr incl
350 - 360	Ls, lt bf, f xl, arg, pyr
360 - 370	Ls, a a to Ls, mgy, mxl, pyr
370 - 380	Ls, a a, brach fos/Sh, lt gy, sft, waxy, calc
380 - 390	Sh, a a tr pyr
390 - 400	Sh, lt gy, calc, pyr, waxy, sft

Interval	Description
400 - 410	Sh, a a
410 - 420	Sh, lt gy, calc, v sft, waxy
420 - 430	Sh, brn - blk, fis, sft, waxy/Sh, a a/ Ls, lt bf, cxl
430 - 440	Ls, lt brn, m xl, fos, few arg ptgs
440 - 450	Ls, lt bf, m xl, white incl sft anhy tr of poros
450 - 460	Ls, a a, poor vuggy por, some arg ptgs
460 - 470	Ls, a a / Sh, lt gn-gy, sft, waxy, sl calc
470 - 480	Sh, a a
480 - 490	Sh, a a
490 - 500	Sh, a a sft, wht anhy
500 - 510	Anhy, sft, wht, fibrous